Atomic Particle Worksheet

Complete the chart by filling in the missing information. Assume neutral atoms.

Name of element	Isotope Symbol	Atomic Number	Mass Number	Number of protons	Number of Electrons	Number of Neutrons
Carbon-12	$^{12}_{6}C$	6	12	6	6	6
Helium-4	$^{4}_{2}He$	2	4	2	2	2
Zinc-65	$^{65}_{30}Zn$	30	65	30	30	35
Gold-197	$^{197}_{79}Au$	79	197	79	79	118
Oxygen-16	$^{16}_{8}O$	8	16	8	8	8
Lead-207	$^{207}_{82}Pb$	82	207	82	82	125
Iodine-127	$^{127}_{53}I$	53	127	53	53	74
Potassium-39	$^{39}_{19}K$	19	39	19	19	20

Atomic Mass Problems

1. Calculate the average atomic mass of sulfur if 95.00% of all sulfur atoms have a mass of 31.972 amu, 0.76% has a mass of 32.971amu and 4.22% have a mass of 33.967amu.

   31.972 x 0.9500 = 30.3734
   32.971 x 0.0076 = 0.2505796
   33.967x 0.0422 = 1.4334074
   32.06 amu

2. There are three isotopes of silicon. They have mass numbers of 28, 29 and 30. The average atomic mass of silicon is 28.086amu. What does this say about the relative abundances of the three isotopes?

   The majority of all naturally occurring silicon atoms are silicon-28 atoms because the weighted average mass (atomic mass) of silicon is closest to 28. The abundances of silicon -29 and silicon-30 cannot be determined from this data, but they are relatively small in comparison to that of silicon-28 because the atomic mass is not much more than 28.

3. The atomic mass of bromine is 79.904amu. One isotope of bromine has an atomic mass of 78.92amu and a relative abundance of 50.69%. The other major isotope of bromine has an atomic mass of 80.92amu. What is the relative abundance of the second isotope?

   $(78.92 \cdot 0.5069) + 80.92x = 79.904$ x=49.31

   Or more simply....100%-50.69% = 49.31%

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Nuclear Decay Reactions

Complete the following nuclear equations and state the type of nuclear decay.

1. $^{210}_{84}Po \rightarrow$ $^{206}_{82}Pb$ $+ ^{4}_{2}He$ — Alpha Decay
2. $^{8}_{5}B \rightarrow ^{8}_{4}Be +$ $^{0}_{+1}\beta$ — Positron emission
3. $^{234}_{90}Th$ $\rightarrow ^{234}_{91}Pa + ^{0}_{-1}e + \gamma$ — Beta Decay
4. $^{14}_{6}C \rightarrow$ $^{14}_{7}N$ $+ ^{0}_{-1}e$ — Beta Decay
5. $^{0}_{-1}e$ $+ ^{81}_{37}Rb \rightarrow ^{81}_{36}Kr$ + X-ray photon — Electron capture
6. $^{15}_{8}O \rightarrow ^{15}_{7}N +$ $^{0}_{+1}\beta$ — Positron Emission
7. $^{58}_{28}Ni + ^{0}_{-1}e \rightarrow$ $^{58}_{29}Cu$ — Electron capture
8. $^{226}_{88}Ra \rightarrow ^{222}_{86}Rn +$ $^{4}_{2}He$ $+ \gamma$ — Alpha Decay

9* $^{1}_{0}n \rightarrow$ $^{1}_{1}p$ $+ ^{0}_{-1}e$ — Beta Decay

10. $^{238}_{92}U \rightarrow$ $^{234}_{90}Th$ $+ ^{4}_{2}He$ — Alpha Decay

Complete the following nuclear equations.

11. $^{9}_{4}Be + ^{4}_{2}He \rightarrow$ $^{12}_{6}C$ $+ ^{1}_{0}n$
12. $^{239}_{93}Np$ $\rightarrow ^{239}_{94}Pu + ^{0}_{-1}e$
13. $^{66}_{29}Cu \rightarrow ^{66}_{30}Zn +$ $^{0}_{-1}\beta$
14. $^{27}_{13}Al +$ $^{4}_{2}He$ $\rightarrow ^{30}_{14}Si + ^{1}_{1}H$
15. $^{141}_{56}Ba \rightarrow$ $^{141}_{57}La$ $+ ^{0}_{-1}e$
16. $^{14}_{7}N$ $+ ^{4}_{2}He \rightarrow ^{17}_{8}O + ^{1}_{1}p$
17. $^{185}_{79}Au$ $\rightarrow ^{181}_{77}Ir + ^{4}_{2}He$
18. $^{241}_{95}Am \rightarrow$ $^{4}_{2}He$ $+ ^{237}_{93}Np$
19. $^{235}_{92}U$ $+ ^{12}_{6}C \rightarrow ^{246}_{98}Cf + 4\,^{1}_{0}n$
20. $^{18}_{9}F \rightarrow ^{17}_{8}O +$ $^{1}_{1}p$
21. $^{2}_{1}H +$ $^{3}_{1}H$ $\rightarrow ^{4}_{2}He + ^{1}_{0}n + energy$
22. $^{27}_{14}Si \rightarrow ^{0}_{-1}e +$ $^{27}_{15}P$
23. $^{214}_{83}Bi$ $\rightarrow ^{4}_{2}He + ^{210}_{81}Tl$
24. $^{32}_{15}P \rightarrow$ $^{32}_{16}S$ $+ ^{0}_{-1}e$
25. $^{142}_{61}Pm +$ $^{0}_{+1}\beta$ $\rightarrow ^{142}_{60}Nd$
26. $^{14}_{7}N +$ $^{1}_{0}n$ $\rightarrow ^{14}_{6}C + ^{1}_{1}p$
27. $^{13}_{6}C + ^{1}_{0}n \rightarrow$ $^{14}_{6}C$
28. $^{239}_{94}Pu + ^{4}_{2}He \rightarrow ^{1}_{1}H + 2\,^{1}_{0}n +$ $^{240}_{95}Am$

Using your knowledge of nuclear chemistry, write the equations for the following processes:

1) The alpha decay of iridium-174

$$^{174}_{77}Ir \rightarrow ^{4}_{2}He + ^{170}_{75}Re$$

2) The beta decay of platinum-199

$$^{199}_{78}Pt \rightarrow ^{0}_{-1}\beta + ^{199}_{79}Au$$

3) Positron emission from sulfur-31

$$^{31}_{16}S \rightarrow ^{0}_{+1}\beta + ^{31}_{15}P$$

4) Krypton-76 undergoes electron capture

$$^{76}_{36}Kr + ^{0}_{-1}e \rightarrow ^{76}_{35}Br$$

Half Life Problems

1) A certain isotope has a half-life of 6.00 hours. How much of a 5.00g sample will be left after 24 hours?

$n = \frac{TE}{t\frac{1}{2}}$ $\frac{x}{5.00g} = \left(\frac{1}{2}\right)^4$ $\frac{x}{5.00} = \frac{1}{16}$ $x = 0.313g$

$n = 24/6 = 4$

2) A certain isotope has a half-life of 3.25 hours. How much of a 10.0kg sample will be left after 3 days?

$n = \frac{TE}{t\frac{1}{2}}$ $n = \frac{72hr}{3.25hr}$ $\frac{x}{10.0Kg} = \left(\frac{1}{2}\right)^{72/3.25}$ $x = 2.14 \times 10^{-6}$ Kg

3) Carbon-14 has a half-life of 5730 years. How long will it take for a 1.00kg sample to be reduced to 0.25kg of carbon-14?

$\frac{0.25Kg}{1.00Kg} = \frac{1}{4} = \left(\frac{1}{2}\right)^n$ $n = 2$ $n = \frac{TE}{t\frac{1}{2}}$ $TE = n \times t\frac{1}{2}$

$TE = 2 \times 5730$

$TE = 11460$ yr

4) A certain isotope of Uranium has a half-life of 4.3 billion years. How long will it take for a 2.7g sample to be reduced to 0.0844g?

$\frac{0.0844}{2.7} = \frac{1}{32} = \left(\frac{1}{2}\right)^5$ $n = \frac{TE}{t\frac{1}{2}}$ $TE = n \times t\frac{1}{2}$

$TE = 5 \times 4.3$ billion yr.

$TE = 21.5$ billion yrs

5) A 0.40g sample of thorium-228 is reduced to 0.05g in 5.7 years. What is the half-life of thorium-228?

$\frac{0.05}{0.40} = \frac{1}{8} = \left(\frac{1}{2}\right)^3$ $n = \frac{TE}{t\frac{1}{2}}$ $t\frac{1}{2} = \frac{TE}{n}$ $\frac{5.7yr}{3} = \sim 2yrs = t\frac{1}{2}$

6) A sample of radon-222 is found to have decreased from 266g to 8.5g in 19 days. Calculate the half-life of radon-222.

$\frac{8.5}{266} = \left(\frac{1}{2}\right)^{\frac{19}{x}}$ $\ln\left(\frac{8.5}{266}\right) = \frac{19}{x}\ln(0.5)$ $x = \frac{19\ln(0.5)}{\ln\left(\frac{8.5}{266}\right)} = 3.8$ days

7) An isotope with a half-life of 8 hours was received exactly 24 hours before it was to be used. At the time of use, the quantity of the isotope was 16.5g. How much of the isotope was there upon delivery to the lab?

$\frac{TE}{t\frac{1}{2}} = n$ $\frac{24}{8} = 3$ $\frac{16.5g}{x} = \left(\frac{1}{2}\right)^3$ $\frac{16.5g}{x} = \frac{1}{8}$ $x = 132g$

8) How long will a 12.4g sample of a radioisotope take to decay to 1.55g if its half-life is 1.2 days?

$\frac{1.55}{12.4} = \left(\frac{1}{2}\right)^3$ $n = \frac{TE}{t\frac{1}{2}}$ $n \times t\frac{1}{2} = TE$ 3×1.2 day $=$ 3.6 days

Induced Transmutation Reactions

Write the following reactions from the given information

1. Alpha particle bombardment of einsteinium-253 (one of the products is a neutron).

$$^{253}_{99}Es + ^{4}_{2}He \rightarrow ^{1}_{0}n + ^{257}_{101}Md$$

2. Induced transmutation of uranium-238 into californium-246 by bombardment with carbon-12.

$$^{238}_{92}U + ^{12}_{6}C \rightarrow ^{246}_{98}Cf + 4^{1}_{0}n$$

3. One induced transmutation reaction of uranium-235 with a neutron results in the release of three neutrons and the production of two new nuclides. One of the nuclides is xenon-138. Write the equation with both reactants and all three products.

$$^{235}_{92}U + ^{1}_{0}n \rightarrow 3^{1}_{0}n + ^{138}_{54}Xe + ^{95}_{38}Sr$$

4. Bombardment of uranium-235 with a neutron can generate tellurium-135, 3 neutrons, and one other product. Write the complete reaction for this transmutation.

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{135}_{52}Te + 3^{1}_{0}n + ^{100}_{37}Rb$$

5. The first radioactive nucleus produced in the laboratory was phosphorus-30. Another product of this reaction was a neutron. This was accomplished through alpha bombardment. Write the complete transmutation reaction including original isotope.

$$^{4}_{2}He + ^{27}_{13}Al \rightarrow ^{30}_{15}P + ^{1}_{0}n$$

6. When sodium-23 combines with hydrogen-2, an alpha particle is produced along with a new nuclide. Write the complete equation for this fusion reaction.

$$^{23}_{11}Na + ^{2}_{1}H \rightarrow ^{4}_{2}He + ^{21}_{10}Ne$$